Letters to the Editor.

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Pathogenic Organisms in the Pollen of Flowers and Disease in Bees.

THE observations of Dr. Rennie and his co-workers have established an association between Acarine infection and Isle of Wight disease in bees. There still remains, however, the question of the part played by bacillary infection in this and other diseases which affect bees. In this communication I desire to direct attention to two aspects only of this complex problem.

(1) In the course of an inquiry during the last three years into an epidemic having many of the features of the so-called Isle of Wight disease, which has caused the loss of a number of my own hives and other stocks in the Midland area, an aerobic short spore-bearing and gram-negative bacillus resembling *B. pestif. apis,* as described by Dr. Malden in the *Journal of Agriculture,* vol. xv., No. 11, February, 1909, was obtained in large numbers from the fæces of affected bees from all the diseased stocks, and was readily grown, sometimes in pure culture, in broth, or on agar or serum agar.

In 1919 I also found that the same organism could be cultured from the sealed cells of the honeycombs from infected hives. A number of cells were opened by removing the cap with a sterilised instrument, and platinum loops of honey taken from these sealed cells were added to broth or smeared on an agar or serum agar slope and incubated at 37° C. for 36 hours. Numerous colonies of the spore-bearing, gram-negative bacillus were obtained from many of the cells. The organism seems to exist in the honey in the spore form only, no bacillary forms being detected before culture, and no cloudiness or discoloration of the honey being produced. In two cases it grew readily when obtained from infected honey cells which had remained sealed for more than twelve months.

The colonies grown from honey resemble those obtained by culture from the fæces of affected bees. They are smooth and white when small, but soon show a corrugated brain-like surface, and may become slightly yellow or pinkish at a later stage.

The fact that, as Dr. Malden showed, the same organism can be obtained from the intestinal contents of apparently healthy bees is important, and I have also grown it from sealed honey cells from apparently healthy hives. Under these conditions the colonies are generally much fewer in number.

This fact is of interest as bearing on the question of bacillary infection in bees, and also on the problem of the inhibitory effect of honey as a culture medium on the growth of organisms, and their persistence in the spore form.

The same organism has also been cultured on the same media from the compressed pollen removed from the thighs of the honey-bee and from several species of humble bee, and also in one case from honey taken from the nest of *Bombus lapidarius.*

(2) The second point has reference to the life-history of the organism outside the body of the bee and the honey cell.

In 1919 I commenced to investigate pollen from various kinds of flowers frequented and avoided by bees, and in the case of frequented flowers both before and after the opening of the flower.

It is impossible here to describe in detail the large number of experiments carried out on different kinds of flowers. Speaking generally, the spore-bearing, gram-negative bacillus described above, together with other bacillary, and in some cases coccal, forms, were frequently grown from the pollen of flowers frequented by the honey-bee, various species of wild bee, and some other insects, while colonies were absent or were sparsely grown from unopened flowers and from flowers such as the edible and sweet pea and others which are not visited by bees to the same extent. Pollen from the pine and other wind-fertilised trees gave very few colonies. From the pollen at the bottom of the spathe of an arum (*Arum maculatum*), in which numerous flies were imprisoned, a small coccus grew freely, in addition to the bacillus form.

There can be no doubt that the anthers and pistils of flowers visited by bees and other insects provide the chief sites of implantation and dispersal grounds for organisms which pass a portion of their life-history in the alimentary canal of bees and in stored honey.

Further investigation is necessary to decide what effect, if any, exposure to atmospheric conditions and to pollen and to plant secretions exercise on the growth of these organisms.

It seems probable that many kinds of flowers, especially open flowers, frequented by bees and other insects harbour enormous numbers of organisms, some of which at any rate are pathogenic to bees under certain conditions, and that a further study of the bacterial flora of flowers would shed light on the diseases of bees and other insects, and possibly on some diseases which affect animals and even man.

C. J. BOND.

The Nature of the Electrical Conductivity of Glass.

IN the course of some work on the electrical conductivity of some dielectrics, which was recently described before the Royal Dublin Society and forms the subject of a forthcoming paper in the *Philosophical Magazine,* the question arose as to the possible electrolytic nature of the current in the case of materials such as glass. The following simple experiment, which is, I think, new, seems worthy of record as affording evidence against this view.

A thin glass bulb about 1·8 cm. in diameter was blown at the end of a piece of tubing, the whole being then filled with a dilute neutral solution of calcium chloride containing a little phenolphthalein. The bulb was immersed in a small beaker of tap-water placed on an insulating stand. Electrodes were placed in the upper part of the tube and in the beaker, one being connected to a source maintained at about −8000 volts with the aid of rectifying valves, and the other to earth through a sensitive galvanometer. Thus a known current could be passed through the glass wall of the bulb in either direction. Currents leaking along the exterior surface of the glass tube were prevented from passing through the galvanometer by an earthed strip of tinfoil gummed round the tube as a guard ring.

The bulb and tube were filled the day before the test was made, and in the interval a slight pink colour had developed, indicating the solution of a little alkali from the glass. The central electrode was first used as anode, so that the glass of the bulb acted as cathode to the solution. If the bulb conducts like a metal, we should expect a red colour to develop on its surface owing to electrolysis of the solution. If, however, the current through the glass

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is purely electrolytic, we should expect the alkalinity to be neutralised by the acid radicle ions driven into solution from the glass. The initial current was 8·5 micro-amperes, rising at the end of fifteen minutes to 13 micro-amperes. By this time the solution in contact with the thinner parts of the bulb was a deep pink. The current was then reversed, the initial value being now 16 micro-amperes. After six minutes the solution in contact with the glass was very nearly, if not quite, colourless. If the current in the glass were electrolytic, there can be little doubt that sodium ions would have been driven into solution, thus maintaining the pink colour. The large changes in the conduction current with time and reversal of direction are probably attributable to alteration and polarisation effects in the glass. The thin parts of the bulb carrying most of the current probably represented an area of only 2 or 3 sq. cm., so that the current density was comparatively large, and the potential gradient probably between 1 and 2 megavolts per cm. The evidence of the colour changes, which were repeated several times, is strongly in favour of the view that under such gradients and at air temperature the conduction current is largely, if not entirely, of a non-electrolytic nature.

Horace H. Poole.

Royal Dublin Society, June 20.

The Displacement of Spectral Lines by a Gravitational Field.

According to the theory of relativity the paths of moving particles or light pulses are geodesics in a four-dimensional Riemann space defined by the metric

$$ds^2 = g_{\mu\nu}dx_\mu dx_\nu.$$

The resulting abstract kinematics is brought into relationship with the facts of experience by the identification of the Gaussian co-ordinates x with the observer's space-time co-ordinates in a Newtonian-Euclidean system. Since the spaces are Euclidean, and since the velocity of light is the same for each observer, it follows that the systems of two different observers are similar, but not necessarily on the same scale.

Consider the field of a single gravitating centre. The metric is given by

$$ds^2 = -\gamma^{-1}dr^2 - r^2[d\theta^2 + \sin^2\theta d\phi^2] + \gamma dt^2.$$

Taking the unit of ds as the fundamental unit, and measuring radial and transverse lengths and times at two different points of the Riemann space, we see that throughout the space the local scale is constant for transverse lengths, varies as $\gamma^{\frac{1}{2}}$ for radial lengths and as $\gamma^{-\frac{1}{2}}$ for times. Since the separated space-time systems of different observers are to be similar, it is clear that their scales cannot be obtained by carrying over the scales of the Riemann space at the observers' world-points. Assume that the observer's time-scale bears to the time-scale at his world-point in the Riemann space the ratio $1 : f(r)$. The scales of the Euclidean systems of two different observers then vary inversely as $\gamma^{\frac{1}{2}}f(r)$.

This variation of scale has no effect on the mercury problem or on the deflection of a beam, but it is of fundamental importance in the third crucial phenomenon, the displacement of the spectral lines.

The usual argument shows that

$$\gamma^{\frac{1}{2}}{}_S dt_S = \gamma^{\frac{1}{2}}{}_E dt_E,$$

where dt_S, dt_E are measured in the units of the Riemann space. If we transfer to the Euclidean spaces of local observers, the equation becomes

$$\gamma^{\frac{1}{2}}{}_S f_S dt_S = \gamma^{\frac{1}{2}}{}_E f_E dt_E.$$

Eddington's argument on p. 129 of "Space, Time, and Gravitation" shows that the time-period *as measured in the units of any one observer* is transmitted by the radiation. Hence dt_S can be compared with dt_E by observation. The measurement of the displacement of the spectral lines determines the function f.

No displacement is to be expected if $f = \gamma^{-\frac{1}{2}}$. In this case, if dt is a time-interval in the Riemann space, $\gamma^{\frac{1}{2}}dt$ is the corresponding observer's interval, and $\gamma^{\frac{1}{2}}dt$ or ds is propagated by the radiation as suggested in my letter of March 10. H. J. Priestley.

University of Queensland, Brisbane, May 11.

The Measurement of Single and Successive Short Time-Intervals.

The following modification of the well-known method of determining small time-intervals by the discharge of an electrical condenser does not appear to be generally used, judging from some inquiries I have had. Though the modification possibly has been published somewhere—the man who can claim originality in these days is fortunate—this letter may be a help to some other workers.

The well-known method to which I refer consists in so arranging the circuit with a condenser and ballistic galvanometer that the former is charged or discharged during the interval. The potential of the condenser is measured before and as soon after the interval as possible by the galvanometer, and the duration of the interval is proportional to the difference of the logarithms of these quantities.

The modification I first used during 1915 in connection with the measurement of the velocity of detonation of explosives consists in connecting one side of the condenser to the string of a Laby string electrometer. The displacement of the string is proportional to the potential of the condenser, so that during an experiment the string falls from one position to another, and the logarithm of the ratio of these displacements from the zero position is proportional to the time. The accuracy of the method can be increased by using a moving plate and photographing the string's position; it can be increased up to the limit imposed by the accuracy within which the condenser capacity and discharging resistance are known by measuring the displacements on the plate with a microscope.

The advantages of this method as compared with the ballistic method are: (*a*) the procedure and circuit are much simplified, (*b*) small leakage is of no importance or embarrassment, (*c*) the whole process being self-recording, the result is available for measurement at any time, and, further, the inertia of the string or its natural period of vibration does not affect the result.

Its disadvantage in common with the ballistic method is the disturbing influence of the inductance of the circuit upon the rate of flow. It may be possible in some applications to calculate this, or to allow for it by calibration.

If a bicycle ball suspended by a long thin wire be allowed to impinge against, and rebound from, the vertical face of an anvil until it comes to rest, the resulting record with its gradually diminishing steps, corresponding to the several durations of contact, affords a pretty example of the application of this method to the measurement of rapidly successive short time-intervals. Alan Pollard.

The Imperial College of Science and
Technology, South Kensington,
S.W.7, June 14.

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